Power, Packaging, and Policy: How the Global AI Compute Race Splits After the GPU Monoculture (2025–2030)

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The era of a single, global GPU monoculture is ending. In its place, we are watching the world sort itself into ecosystems—each defined as much by energy, packaging, and interconnects as by raw FLOPS. Export controls narrowed supply, but the deeper forces are practical: where to find firm, affordable power; how to stack memory close to compute; how to move tensors across a fabric without wasting time; how to keep software gravity from pinning everyone to one vendor forever. The result is not collapse but a re-balancing. China's accelerators mature first on the workloads that matter most at home; the U.S. and allies keep a lead at the frontier by compilers, toolchains, and advanced packaging; a rising South knits heterogeneous clusters where permits are fast and power is cheap. Between them runs a thin braid of compatibility—enough to keep commerce moving, not enough to erase differences. This paper maps that shift. It tells the story in human terms: builders choosing sites and fabrics, policymakers trading guardrails for growth, communities weighing jobs against megawatts, and researchers translating models across dialects of the same idea. What emerges is a practical coexistence: fragmented parity, held together by need.

Keywords: AI compute, export controls, sovereign compute, advanced packaging, HBM, interconnects, cluster fabrics, energy policy, data center siting, CUDA, MindSpore, PaddlePaddle, tool sovereignty, ASML, EDA, vertical integration, heterogeneous acceleration, telco inference, procurement, fragmented parity, global ecosystems,

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1. Thesis and Frame

1.1 From global uniformity to regional ecosystems

For a decade, AI compute felt like a single language with one preferred accent. The hardware came from a narrow set of vendors, the kernels were written against familiar libraries, and the gravity of a dominant software stack pulled everyone into the same orbit. That era produced tremendous speed, but it also hid fragility: common failure modes, shared bottlenecks, and a dependency chain that ran through the same factories, the same memory suppliers, the same interconnects, the same compiler assumptions.

What changed first was not ideology but possibility. Regions discovered that they could not count on identical parts arriving on identical timelines. The response was pragmatic: swap uniformity for sufficiency. Instead of one global stack, we now see ecosystems shaped by local constraints and advantages—power, water, packaging capacity, toolchains, and procurement culture. A telco's inference farm in one country does not need the same recipe as a frontier-training lab in another; a university cluster chasing fluid dynamics is different again. Each ecosystem chooses its "good enough" for the things it most needs to do.

This is less a divorce than a branching. Interfaces remain; ideas travel; models get translated. But the defaults no longer match. Software becomes bilingual or trilingual. Clusters are designed for the workloads that pay their bills. The result is a world of overlapping circles rather than one giant disc: regional, purpose-built, and more resilient precisely because it is not the same everywhere.

1.2 Why power, packaging, and policy now decide the race

In the early days, the story was FLOPS. Today, the story is flow: the flow of electrons, the flow of heat, the flow of tensors, and the flow of permits. **Power** comes first because every other promise depends on it. A site with firm megawatts, fast interconnect to the grid, and a clear cooling plan can host ambition; a site without them is theatre. The most competitive builders write energy into the design brief: co-siting with generation, long-horizon PPAs, transmission upgrades negotiated alongside land.

Packaging comes next because proximity is performance. Stacking memory close to compute, routing signals through 2.5D and 3D assemblies, and managing yield without breaking the cost curve—these are no longer esoteric manufacturing details. They are where latency is shaved, bandwidth is born, and total cost is decided. The advantage shifts to those who can marry design with advanced assembly at scale, turning supply into sustained throughput.

Finally, **policy** sets the boundary conditions. Export regimes, tool access, environmental reviews, and public procurement do not merely slow or speed a project; they change which projects are

possible. A rule can make a chip unavailable; a licensing path can make an alternative inevitable. A permitting reform can shorten time-to-energize by a year; a water constraint can redirect a region's entire siting map. When power, packaging, and policy align, the road is downhill. When they do not, even the fastest chips move slowly.

1.3 "Fragmented parity" as the baseline, not the failure mode

It is tempting to treat divergence as decline: if the world is not using the same parts, someone must be falling behind. But parity does not require sameness; it requires sufficiency against purpose. A nation that can train its largest models on domestic accelerators, serve inference to its biggest industries, and keep the cadence of improvement is not failing because it uses different tools. It is succeeding on its own terms.

"Fragmented parity" names this new baseline. In it, multiple ecosystems reach comparable outcomes on the tasks they prioritize, even if their paths differ. One region wins on frontier efficiency; another wins on cost-per-token at national scale; a third wins on time-to-permit and deploy. There are bridges—common file formats, portable graph compilers, shared research—but there is no single center that must bless every move. The system is more modular, more political, and, paradoxically, more stable.

Seen this way, the end of monoculture is not an error message. It is an adult architecture. It tolerates disagreement. It routes around scarcity. It invites local optimization without forbidding collaboration. And for the next stretch of history, it is how progress will actually happen: not as a universal march behind one flag, but as parallel climbs up different faces of the same mountain, with ropes thrown across when the weather allows.

2. A Short History of Concentration

2.1 How one stack won: compilers, kernels, and developer mindshare

The triumph of a single stack was not ordained; it was patiently engineered at three layers that mattered most to builders in a hurry. First came **compilers and toolchains** that hid the pain. A coherent path from high-level frameworks to device code meant researchers could write in familiar Python and trust the backend to do the hard work—fusion, tiling, scheduling, vectorization—without thinking like a hardware engineer. Second came **libraries of hand-tuned kernels** for the primitives everyone used: convolutions, attention, matrix multiply, reductions, collectives. Each release squeezed more performance from the same silicon, so workloads got faster even when budgets did not. Third came **mindshare**, the soft power that follows working demos and quick wins. University courses, sample notebooks, conference tutorials, and cloud

credits trained a generation to think in one mental model. Portability existed on paper; velocity lived in one neighborhood.

Ecosystem effects compounded. Hardware launches were synchronized with kernel updates; frameworks adopted new ops as soon as they were stable; profiling tools diagnosed bottlenecks in a language developers spoke. Startups planned roadmaps around public timelines; cloud providers built SKUs around the same cadence. The result was a pleasant illusion: "AI" looked like a single place you could go, with a single dialect you had to learn. Underneath, that place was a web of fabs, memory suppliers, and packaging houses—but the surface felt like one door with one key.

2.2 The shock: rules that narrowed choice, and what they actually changed

The first jolt was not a shortage; it was a **boundary**. Export rules drew a bright line through what had previously been a global parts bin. Overnight, chips were renamed, bins were split, and "availability" gained a new meaning: permitted here, restricted there, or allowed only in detuned form. The most visible effect was on procurement—buyers could no longer assume that the best part on a slide would be the part in a crate. But the deeper change was psychological. Roadmaps that had once felt like physics—predictable, incremental, clockwork—now felt like policy—conditional, contingent, revisable.

Then came the **toolchain shock**. Designers discovered that losing access does not just mean losing a component; it can mean losing the **ability to improve** the component you still have. When EDA access, IP blocks, or packaging capacity are gated, iteration slows. And when iteration slows, confidence erodes. Some teams paused and waited. Others pivoted and built. Either way, the spell of inevitability broke. The market learned that "choice" had always been narrower than it looked, held together by licenses and logistics as much as by physics.

Practically, three things shifted. **Budgets** moved from buying the newest part to extracting more from what was already installed. **Software** became the first lever: quantization, sparsity, compiler passes, layout tricks, graph rewrites. And **risk** was re-priced. A second stack that was once a curiosity became an insurance policy. Diversity, long dismissed as wasteful redundancy, started to look like uptime.

2.3 The quiet pivot from chips to fabrics

As constraints tightened, attention slid—quietly, decisively—from the individual device to the **fabric that binds many devices**. The unit of progress became the **pod**, not the chip; the KPI shifted from peak FLOPS per device to **tokens per joule per rack** and **time-to-answer at cluster scale**. Builders discovered that a mediocre device in a great fabric can beat a great device in a congested one. Bandwidth, latency, topology, failure domains, and scheduler behavior began to decide who finished training in weeks and who needed a quarter.

This reorientation made **interconnects and packaging** the new center of gravity. HBM proximity, 2.5D/3D assembly, retimer budgets, optical links, and topology-aware placement turned into everyday vocabulary. Collective communication libraries and graph compilers mattered as much as silicon; so did **orchestration**—the unglamorous craft of keeping thousands of accelerators busy despite stragglers, faults, and hot spots. Pipeline/tensor sharding, mixture-of-experts routing, checkpoint choreography: these became the real art, because they amplified whatever hardware you actually had.

The cultural shift was just as important. Teams stopped asking "What is the fastest chip?" and started asking "What cluster can we **build, power, and keep full**?" Power purchase agreements, substation timelines, and water plans sat beside model specs in the same deck. Fabric designers met compiler writers; facilities engineers met research leads. In that crossing, a new hierarchy emerged: **power → packaging → fabric → device**. The industry did not announce the pivot; it lived it, one rack plan and training curve at a time.

3. The Four Levers That Matter

3.1 Power: firm supply, fast permits, water and community impact

Every aspiration in AI collapses to one practical question: can you energize it? "Firm" power—capacity that is there on bad days as well as good—turns roadmaps into reality. Builders now court grids the way manufacturers once courted ports: long-horizon PPAs, on-site generation, and transmission upgrades negotiated before the first rack is specced. Speed matters almost as much as price. A site that can be energized in 18 months often beats a cheaper site that needs three years of hearings and a new substation.

Water is the second meter. Evaporative cooling saves watts but spends water; liquid loops spare water but ask for higher capex and tighter maintenance skill. Local hydrology, climate, and policy shape the answer. Communities notice both the draw and the give-back: tax base, jobs, noise, heat plumes, and whether the operator invests in shared infrastructure (district cooling, reclaimed-water projects, battery storage that stabilizes everyone's lights). The best projects show up early, price externalities honestly, and leave the place better—grid flexibility in exchange for megawatts, local upskilling in exchange for land.

3.2 Packaging: 2.5D/3D, HBM proximity, yield and cost curves

Performance is now manufactured in millimeters. Putting memory close to compute—HBM stacks on 2.5D interposers, or deeper 3D assemblies—decides how much useful work crosses a die boundary and how much gets stranded waiting on bandwidth. The allure is obvious: shorter paths, fatter pipes, lower latency. The catch is also obvious: yield and cost. Every bump, via, and

retimer is a chance to miss; every added layer compounds risk. Leaders treat packaging like a product, not a postscript—qualifying multiple substrates, designing for testability, and tuning layouts to the realities of assembly, not just the dreams of simulation.

The economics are nonlinear. At small scale, exotic packaging looks expensive; at cluster scale, it can be the cheapest way to buy time. When HBM is scarce, smart firms redesign memory hierarchies and operator schedules to use it where it matters most; when assembly capacity tightens, they simplify bills of materials to keep throughput predictable. The packaging win is rarely in a press release. It shows up in steadier lead times, fewer field failures, and training jobs that converge without mystery stalls.

3.3 Interconnect: bandwidth, latency, topology, and scheduler maturity

Once you have a room full of accelerators, the network is the computer. Raw bandwidth headlines are misleading if latency is spiky, topology is mismatched to your parallelism, or the scheduler can't keep stragglers from dragging the average. Collective communications (all-reduce, all-gather, scatter, broadcast) punish uneven fabrics; a single oversubscribed link can turn an impressive spec sheet into a queue.

Designers now start with the workload and work backward to the map: tensor vs. pipeline vs. data parallelism, mixture-of-experts routing patterns, checkpoint cadence, and failure domains. Do you want dragonfly, fat-tree, or a custom mesh? Are links optical where they should be and electrical where they can be? Can your job manager reorder work when a leaf goes flaky without poisoning the whole run? Scheduler maturity is the quiet multiplier. Good schedulers overlap compute and comms, balance shards by real—not theoretical—device speeds, and adapt when the cluster isn't the same in week two as it was on day one. In this world, an average chip on an excellent fabric often beats an excellent chip on an average fabric.

3.4 Software Gravity: frameworks, graph compilers, and portability in practice

Developers live where the code runs easily and gets faster every quarter without heroic effort. That is software gravity. Frameworks set the ergonomics; graph compilers and runtimes turn intent into execution plans that match the silicon you actually have. The old dream of "write once, run anywhere" is giving way to "write once, **optimize** anywhere": stable frontends with backend-specific passes that fuse ops, schedule kernels, and map collectives intelligently to the fabric.

Portability is not a manifesto; it's a migration day that feels boring. If moving a model means a handful of import changes and a week of profiler-guided tweaks, people will do it. If it means rewrites, they won't. That is why compatibility layers, ONNX-style IRs, and vendor-maintained bridges matter—not as marketing slideware, but as living code that tracks new ops, quantization schemes, sparsity patterns, and mixed-precision rules. The winners make the fast path the easy

path: good defaults, clear traces, guardrails that keep a clever trick from backfiring in production. In practice, this is how ecosystems coexist: frameworks teach a common language; compilers translate the accent; clusters do the talking.

4. Three Paths to 2030

4.1 Fragmented Parity: good-enough excellence inside each ecosystem

By 2030, the most likely world is one where different regions master the parts of AI that matter most to them and stop waiting for permission to match someone else's playbook. Parity arrives not as identical hardware, but as **capable stacks**: accelerators that are "fast enough," compilers that are "smart enough," clusters that are "big enough," and costs that make sense for local priorities. Frontier labs in one bloc chase training efficiency at the very edge; national clouds in another optimize for **cost-per-token** and **predictable rollout**; science centers elsewhere prize **portability** and **open methods** over raw speed.

What ties this together is cadence: each ecosystem learns to ship improvements on a reliable drumbeat, even if the absolute numbers differ. APIs and formats keep ideas flowing across borders, but nobody is frozen while they wait. The virtue of this arrangement is resilience. If a part goes scarce or a rule tightens, there is another route around the mountain. Progress becomes plural: many paths upward, with the occasional shared ledge for rest and exchange.

4.2 Selective Re-coupling: narrow bridges for mid-tier parts and tools

Total separation is expensive and, in the long run, brittle. The second path is a quietly negotiated middle: **narrow bridges** that restore some commerce without reopening the frontier. Think mid-tier accelerators for enterprise inference, EDA/tool access under tight guardrails, reference interconnects that stop short of bleeding-edge secrets, and shared formats that make model migration dull rather than dramatic.

This is not détente so much as **civics for technology**: rules that acknowledge mutual need while preserving red lines. It benefits everyone who lives in the middle of the market—banks, telcos, hospitals, governments—who care more about service levels and compliance than about shaving the last percent of training time. It also disciplines excess: when bridges exist, political shocks are less likely to break entire supply chains. The risk is complacency; the opportunity is stability. If done well, selective re-coupling lowers the temperature enough for engineers to get back to work.

4.3 South-Led Heterogeneity: multi-vendor clusters where energy wins

A third path is already visible along the new energy corridors: **India, the Gulf, parts of Southeast Asia, Latin America, and Africa** building clusters that mix and match whatever

works—Nvidia here, domestic there, China-made somewhere else—tied together by aggressive siting, fast permits, and firm power. In these places, the differentiator isn't branding; it's **megawatts and months**. If a campus can be energized in under two years and fed for decades, the compute will come, and with it the skills, the startups, and the sovereign stacks. Heterogeneity is not a drawback; it is a moat. Multi-vendor fabrics teach teams to treat portability as muscle memory and scheduling as art. Local universities tune models to local languages and industries, anchoring ecosystems that are proud of their specificity. Some sites grow into **export engines** for AI services; others become sanctuaries for science that cannot wait on someone else's queue. The global effect is a re-centering: prosperity follows electrons, and the South's energy pragmatism turns into technological gravity.

5. Region by Region

5.1 United States & Allies: frontier training, toolchains, and grid constraints

The United States and close allies still anchor the frontier: top-end accelerators, the richest compiler and kernel ecosystems, and the deepest bench of teams that can turn new silicon into new science. Here, progress looks like cadence—new packaging generations, tighter graph compilers, larger superpods that bring training times down from months to weeks. Universities, startups, and hyperscalers share a common language; the same conferences and open-source repos keep the feedback loop fast. When the latest attention variant appears in a preprint, someone has the toolchain to benchmark it by morning.

The pressure point is the grid. Time-to-energize, transmission bottlenecks, and water politics govern how quickly capacity can turn from slideware into racks. States and provinces with faster permits and friendly utilities become magnets; others watch projects slip a fiscal year. In this bloc, policy isn't a debate about chips so much as a race to connect substations, line up firm megawatts, and cool responsibly. The winners treat electrons as part of the R&D stack: power procurement is a design decision, not a back-office chore.

Allied geographies—Japan, South Korea, Canada, Australia—extend this lead with specialized strengths: advanced memory, packaging, photonics, clean power, or regulatory clarity. The shared advantage is cultural as much as technical: a long habit of interoperable tooling, research norms that travel well, and markets that reward portability. Frontier training belongs here for now, provided the grid catches up.

5.2 China: workload-specific scale, vertical integration, and domestic fabrics

China's strength is scale with direction. It optimizes for the workloads that matter most at home—LLM training and inference, telecom-grade AI, computer vision for industry—and then

builds full stacks around those needs. Vertical integration is not a slogan but an operating model: domestic accelerators paired with in-house frameworks, domestic clouds tuned for the fabric, and procurement that multiplies once a stack proves itself. The emphasis is on throughput, cost predictability, and the confidence that if a bottleneck appears, you can change both the software and the silicon to relieve it.

This approach yields quick wins where the problem shape is clear and the users are many. State-owned enterprises and national platforms become anchor tenants that force maturity: high availability, service guarantees, and performance on specific tasks that are boring only because they work. The ambition is cumulative—chip revisions feed back from production logs; compiler passes capture every trick discovered in deployment; interconnects evolve to match real traffic rather than ideal theory.

The challenge is breadth. General-purpose parity across every research domain will take longer, and some toolchain chokepoints remain stubborn. But the fabric-first mindset keeps the curve rising. Where the West prides itself on the newest peak, China prizes the flattest plateau: large, steady, and improving on schedule.

5.3 Europe & UK: lithography leverage vs. siting friction; hubs that break through

Europe and the UK hold a strategic lever few others touch—core lithography and metrology know-how, precision manufacturing cultures, and a standards mindset that travels into regulation and safety. Their research institutes and national labs punch above their weight in algorithms, robotics, and scientific computing. On paper, this should be an easy springboard into sovereign compute at scale.

The drag is siting friction: permits that take years, electricity prices that wander, and local processes that distrust speed. Yet across the map, bright hubs break through. Where utilities, cities, and research campuses align, clusters rise quickly with clean power, excellent connectivity, and a stable workforce. These places specialize: some become packaging or photonics champions; others host scientific AI that values reproducibility over record-breaking speed. The European virtue is reliability—systems that meet declared SLAs, data protection you can explain, and a civic contract that earns longevity.

If Europe and the UK can compress permitting timelines without abandoning their protections, they will anchor a third model of leadership: not the fastest or the cheapest, but the most trusted—ideal for health, finance, and science where traceability matters as much as tokens per second.

5.4 India, GCC, Southeast Asia, Latin America, Africa: permits, PPAs, and sovereign ambition

Across the Global South, the differentiator is not a single vendor but a way of building: **permits that move**, **PPAs that last**, and a willingness to mix whatever works into a single campus. These regions win by translating energy into opportunity. If a site can guarantee power, water, and fiber on a timeline measured in quarters, capital and talent will find it. The result is pragmatic heterogeneity: Nvidia beside domestic accelerators, China-made parts beside U.S. stacks, all woven into fabrics that prize uptime and cost control.

India leans on its software class and public digital rails, turning national platforms into anchor customers for sovereign models. The Gulf converts energy abundance into compute abundance, pairing on-site generation with heat-reuse and water-smart cooling. Southeast Asia supplies agility and cross-border redundancy; Latin America and Africa add new languages, new markets, and room to grow with fewer historical constraints. Universities and technical institutes in these regions become translators: tailoring models to local needs—agriculture, logistics, education, health—while training a workforce fluent in multi-vendor operations.

What begins as catch-up often becomes export. Clusters that can host anyone can serve everyone, selling compute, services, and expertise beyond their borders. Sovereign ambition matures into a durable position: not as the place with the newest chip, but as the place where ideas become running systems—quickly, affordably, and on terms set close to home.

6. Who Buys the Most and Why

6.1 Telcos and finance: inference first, reliability always

Telcos and banks live in the land of the nonstop SLA. Their core loops—routing traffic, scoring risk, catching fraud, answering customers—are **inference-heavy** and fiercely latency-sensitive. A hundred milliseconds here is revenue there; a minute of downtime can become a morning headline. That's why these buyers care less about frontier training records and more about **predictable throughput, low tail-latency, and graceful degradation** when hardware, links, or models misbehave. They favor mature stacks, battle-tested orchestration, rolling upgrades, and **observability that talks back** in human time.

Procurement follows the same logic: conservative on new silicon, bold on **fleet efficiency**—quantization, distillation, caching, and clever request shaping. They will pay for redundancy twice before gambling once on fragile novelty. If a domestic accelerator proves stable on a small set of well-defined services (voice bots, KYC, network optimization), adoption can scale fast—because **reliability is the currency**, and every extra nine of availability buys trust they can spend with regulators and customers.

6.2 Public sector and science: sovereignty, standards, and budget cycles

Governments and research institutions buy for **continuity and control**. They need systems that are explainable to auditors, repeatable for peers, and secure enough to sleep at night. In practice, that means **sovereign options** where possible, **open standards** where prudent, and long support tails that survive an election or two. They value transparent roadmaps, documented interfaces, and the right to move workloads when policies or partnerships change. Their cycles are slower, but their commitments are deeper. A national lab or health agency that standardizes on a stack will **anchor an ecosystem**: training programs, local vendors, and shared repositories that outlast the first wave of hype. Performance matters, but **traceability and reproducibility** matter more—provenance of data, stability of compilers, determinism in training runs. These buyers will trade a few percent of speed for a decade of clarity, and they will defend that choice when fashions shift.

6.3 Consumer internet and foundation labs: cadence, capex, and risk tolerance

Consumer platforms and frontier labs run on **cadence**—new models, new features, new reasons to refresh the feed. Their calendars are measured in product launches and research sprints, so they optimize for **time-to-deploy** and **time-to-result**. They are willing to take calculated risks on fresh silicon, novel packaging, or aggressive cluster fabrics if it shortens the path from idea to impact. Capex is large but purposeful: pay more now to move faster all year.

Two temperaments live here. **Consumer internet** wants elasticity first—autoscaling inference fleets, A/B safety nets, and cost curves that won't punish success when usage spikes. **Foundation labs** want headroom—interconnects that won't bottleneck the next trillion-token run, compilers that tame exotic architectures, and facilities that can swallow the next power step without drama. Both groups are happy to be early—**if** the software path is real: graph compilers that land on time, debuggers that see across thousands of devices, and portability that turns vendor risk into a footnote.

Their rule of thumb is simple: ship the model, then refine the margin. When cadence is king, the winning stack is the one that lets them **move, learn, and move again**—without asking permission from the calendar or the grid.

7. The Economics of Sovereign Compute

7.1 Build vs. buy: when in-house silicon makes sense

Owning silicon is a promise and a burden. It makes sense when three conditions line up: **volume**, **variance**, and **voice**. Volume means you will buy enough accelerators over enough years that the non-recurring costs—architecture, verification, tool flows, masks, packaging qualification—get diluted into a sensible per-unit figure. Variance means your workloads are

stable and distinctive enough that a custom design can cut away general-purpose fat—memory hierarchies, data paths, and precision modes you do not need—and redirect that silicon to what you do. Voice means you can change the roadmap when reality speaks: if production logs show a bottleneck in collectives or cache behavior, your design team can alter the next tape-out and your compiler team can meet it halfway.

If any of those three go missing, buying wins. Low volume turns custom chips into vanity projects. Rapidly shifting workloads punish specialization. No architectural "voice" reduces you to a brand name on someone else's die. Even when all three align, time is the silent cost. Tooling talent, bring-up labs, firmware, driver stacks, compilers—these take seasons to mature. The smarter path for many is staged sovereignty: start with firmware and compilers on third-party silicon, move to board-level control, then only later to your own die when the learning curve and the savings curve finally cross.

In practice, "build" rarely means pure autarky. It means **co-design**: you own the parts of the stack where your differentiation lives (formats, kernels, runtime policy), and you partner where the supply chain is deep (HBM, substrates, packaging). The goal is not a museum piece with your logo; it is a fleet you can afford, understand, and steadily improve.

7.2 The real TCO: power, cooling, packaging, interconnect, and people

The invoice on day one is not the cost of year five. Total cost of ownership starts with **power**—not just kWh, but **firm capacity**, demand charges, and the price of delays while you wait for a substation. Energy contracts that look identical on paper diverge in practice when weather, curtailment, or grid constraints arrive. Next comes **cooling**. Evaporative designs are cheap and thirsty; liquid loops are capex-heavy and water-light. Climate, regulation, and local sentiment make one or the other pay off. Either way, heat you can reuse—or at least discharge without conflict—lowers the social and financial bill.

Packaging now sits on the cost curve as plainly as silicon. Yields on advanced assemblies, HBM availability, substrate lead times, retimer budgets: each affects unit price and—more importantly—delivery certainty. Teams that treat packaging as a living constraint, not an afterthought, avoid the most expensive cost of all: idle clusters waiting for one missing part. **Interconnect** adds its own economics. Oversubscribe the wrong place and you buy accelerators that sit in queues. Spend wisely on fabric and schedulers and you reduce the fleet you need for the same work.

Finally, the least fungible line item: **people**. Compiler engineers who can squeeze a graph into your memory hierarchy; SREs who can land upgrades without visible seams; facilities teams who can keep water, power, and safety in balance over decades. Talent retention is a TCO multiplier in both directions. The right few make everything cheaper; churn makes even perfect hardware

feel slow. When you add it all up, smart buyers stop asking only “How much per chip?” and start asking “How many months to energize, how many tokens per joule, and how many people to keep it true?”

7.3 Procurement as destiny: how large buyers create platforms

Markets follow their anchor tenants. When a telco, ministry, bank, or hyperscaler writes a multi-year **RFP** with clear SLAs, telemetry requirements, and integration standards, they are not just buying boxes—they are **founding a platform**. Vendors shape roadmaps to win that business; toolmakers add passes and profiles to meet the logs that contract demands; regional partners train talent to the chosen stack. The second-order effects matter most: once a critical mass of deployments share the same runbooks and APIs, an ecosystem congeals—third-party monitoring, optimized models, certified boards, a cadence of updates people can plan around.

This power cuts both ways. A sloppy RFP can freeze bad assumptions into cement; a thoughtful one can bend the industry toward reliability and openness. Procurement that insists on **observability**, **portability**, and **graceful degradation** rewards vendors who engineer for real life. Procurement that asks only for peak benchmarks buys pain. De-risking is not about picking a winner; it is about specifying **escape hatches**: dual-sourcing, compatibility layers, data and model formats that make migration boring, and penalties that activate when promises drift.

Large buyers also decide **who gets to learn**. Award a pilot and disappear, and you get a press release. Award a series of measured expansions with public post-mortems, and you get a community that knows how to operate. Over time, that know-how becomes a comparative advantage wider than any single contract. In this sense, sovereign compute is not just a budget item. It is a civic act: using purchase orders to turn a wish for capability into a living, local competence that lasts beyond a product cycle and outlives a headline.

8. Security, Trust, and Rules

8.1 Tool sovereignty without isolation

Sovereignty begins with the right to keep building when the weather changes. It is the ability to compile, test, sign, and ship without asking anyone’s permission, and to debug the full stack—from firmware to framework—inside your own walls. But sovereignty does not require a siege mentality. The lesson of complex systems is that **self-reliance and interdependence can coexist**. You keep a domestic path for critical tools—compilers, kernels, graph IRs, signing services—so essential work never stalls. At the same time, you maintain **dual fluency** in external ecosystems where it is safe and efficient to do so.
The practice looks ordinary and disciplined: mirrored package registries; local license servers

and air-gapped build farms; reproducible builds with attestations; SBOMs that are checked, not filed; and internal forks of key open-source components maintained by teams who actually upstream fixes. Contracts formalize the rest: escrow for critical code; exit clauses that trigger when access is curtailed; and performance obligations tied to telemetry you control. The aim is simple—**no single point of political failure**, without cutting yourself off from the global stream of ideas and improvements.

8.2 Guardrails that guide rather than walls that split

Rules are tools, and good tools shape hands rather than tie them. The best guardrails **steer behavior without freezing invention**. They set clarity, not traps: which data can cross which boundary; which models need human review; which logs must be retained and which must be forgotten. They ask for evidence you were careful—provenance, red-team records, evaluation reports—without dictating a single recipe for every lab or workload.

Walls, by contrast, create black markets and brittle workarounds. When a rule forbids the ordinary, people route around it until the system becomes opaque. So the art is proportion: **high friction where harm concentrates, low friction where benefit scales**. That might mean tiered deployment gates for foundation models, automatic containment for unknown code paths, and lightweight approvals for modifications that can be rolled back safely. In procurement, it means rewarding vendors for **observability and reversibility**: if you can see how it works and you can unwind it when it doesn't, you can afford to move faster. Guardrails that teach are kept; walls that merely punish get climbed.

8.3 The thin braid: APIs, formats, and norms that keep trade possible

Even in a world of rival stacks, a narrow corridor must stay open: **the thin braid** of shared interfaces that lets work cross borders without dragging politics with it. Three strands matter. **APIs** that are stable enough to plan against—model serving, batch training, telemetry export—so that tools around them don't shatter every quarter. **Formats** that travel—weights, datasets, traces—capturing enough structure to be useful while leaving room for backend-specific magic. And **norms** that carry trust—mutual disclosure about evaluations and known failure modes; routine third-party audits of safety claims; signed attestations for builds and datasets so provenance is checkable, not mystical.

This braid is not a treaty; it is a habit. Vendors publish IR specs and conversion tools that actually work. Labs share minimal, verifiable proofs of safety and performance rather than slogans. Buyers insist on **boring migration days**—the kind where a model ports with a short checklist and a long nap, not a heroic rewrite. Over time, the braid thickens. Trade continues—narrow, practical, and resilient—because the interfaces are honest and the expectations are clear. That is how trust survives rivalry: not with grand declarations, but with small, sturdy agreements that keep the world working.

9. Land, Water, and Heat

9.1 Grid realities: substations, transmission, and time-to-energize

The limiting reagent is seldom racks; it is **energization**. New load above a few tens of megawatts usually needs a **dedicated substation**, sometimes a new **high-voltage intertie**, and almost always a place in an **interconnection queue** that moves on utility, not startup, time. Transformers are long-lead items; switchgear and protection studies add months. Add **N-1 reliability** (keep running after a single failure) and your single line diagram gets more complicated—and more expensive.

"Cheap power" on a slide can still be **stranded** by **transmission congestion** or seasonal **curtailment**. Smart builders underwrite their schedule with multiple levers: stageable load blocks (50–100 MW at a time), **behind-the-meter** generation or storage to shave peaks, and **grid-service participation** (demand response, fast frequency response) that turns flexibility into revenue while making interconnection easier to approve. The project plan should treat **time-to-energize** as a design parameter: scout sites with spare capacity, co-permit substation and campus, and model contingency paths (temporary feeders, mobile transformers) so the cluster doesn't wait on a single bottleneck.

9.2 Cooling choices and local climate

Cooling is not a fashion statement; it is **climate mathematics**. In cool, dry regions, **air or adiabatic cooling** can carry most loads; in hot or humid climates, **direct-to-chip liquid** becomes the safe default. **Immersion** shines for dense, uniform loads but asks for fluid management expertise and careful service procedures. Each path trades watts for water, capex for opex, and simplicity for density.

Two questions anchor the decision: (1) **What does summer look like here in 2030?** Design to future weather, not last decade's averages. (2) **Where does the heat go?** If you can **reuse heat** (district heating, greenhouses, industrial processes), your cooling plant turns from a cost center into a local asset. If not, plan **plume abatement**, noise attenuation, and **thermal discharge** permits early. Water policy is as decisive as meteorology: reclaimed-water loops, brine management, and **make-up water guarantees** will pass or fail your environmental review. The winning designs pick a primary cooling mode, plus a **graceful fallback** for outages and heat waves, and instrument everything so drift is seen before it becomes downtime.

9.3 Community terms: wages, noise, and shared infrastructure

A campus survives on **social license**. Communities do not buy FLOPS; they buy **jobs, quiet nights, and better services**. Put that in writing. Modern projects open with a **community benefits agreement** that names wages and apprenticeships, funds **workforce training** with local colleges, and schedules heavy construction to spare schools and hospitals. **Noise** is a contract,

not a hope—spec targets in dBA at the fence line, nighttime limits, baffles and berms designed before the first fan ships.

The most durable bargain is **shared infrastructure**. If your substation ups capacity, reserve feeders for municipal growth. If you trench for fiber, over-pull and dedicate strands to public uses. Pair **battery storage** with the campus to flatten local peaks and bolster resilience; invest in **reclaimed-water plants** that serve both data center and city. Publish **environmental telemetry** (water draw, discharge temperature, noise, waste heat) on a public dashboard. Train and fund the local **fire and emergency services** for liquid cooling and high-energy electrical incidents. Communities remember who showed up with more than a ribbon.

In short: schedule power like product, choose cooling for the climate you're entering, and **treat neighbors as partners**. Land, water, and heat are not just engineering constraints—they are the terms on which the future is allowed to be built.

10. Signals to Watch (Told in Plain Language)

10.1 Where the next big campuses break ground

Watch the dirt, not the decks. Real momentum shows up as fenced rectangles, crane rentals, and crews working weekends. The telltales are simple: utility trucks at a new substation pad, concrete for chilled-water plants, and a flurry of job posts for electricians, pipefitters, and commissioning engineers. When a region starts approving 50–100 MW blocks in sequence, that place is about to matter. Bonus signals: long-term power contracts announced quietly by the local utility, new transmission studies on public calendars, and city council minutes that mention road widenings and reclaimed-water tie-ins. If three neighboring parcels file similar permits within a quarter, a campus cluster—not a one-off—is forming.

10.2 Packaging and HBM lead times easing—or not

You don't need a factory tour to read this one. Lead times drift into everyday conversation: "We can ship in March," becomes "maybe Q3," or it snaps back to "we have capacity next month." Procurement folks stop hedging in their emails; integrators talk less about "allocation" and more about "standard delivery." RMA rates on advanced modules flatten. Press releases brag less about peak FLOPS and more about "steady supply." If OEMs start offering multiple substrate options again—and reference boards stop changing every revision—that's a sign the packaging bottleneck is loosening. If, instead, you hear about substrate swaps, binning gymnastics, and "please accept this alternative memory stack," plan for tightness to linger.

10.3 Compiler/runtimes that make porting dull (and therefore real)

Portability is real when it's boring. The signal is a migration that fits into a sprint: import stays the same, a small set of flags changes, and the profiler heatmap looks familiar on day two. Engineers start complaining about model choices again instead of kernel quirks. Release notes get shorter and more predictable; "known issues" move from red boxes to footnotes. The strongest sign is cultural: teams stop asking "Should we?" and start asking "When do we?" You'll also notice fewer heroic blog posts about custom patches and more routine changelogs about fused ops, mixed-precision defaults, and collective tuning that "just works" across fabrics. When the hard parts go quiet, the compilers are doing their job.

10.4 State-owned and national buyers repeating orders, not piloting

Pilots are press; repeats are policy. The signal is the second and third purchase from the same public buyer—bigger lots, stricter SLAs, fewer caveats. Tender language shifts from "trial" to "expansion," from "proof-of-concept" to "standard configuration." Training programs appear around the stack: vocational courses, certification tracks, civil-service job codes. Vendors start moving support teams on-site because the log volume justifies it. If a national telco, a ministry, or a public cloud renews with the same accelerator and adds a second region, a platform has been crowned. That's when downstream suppliers align, local integrators grow up fast, and everyone else in the country quietly updates their plans to match.

11. Nine Forecasts, Narratively

11.1 Two strong ecosystems with bridges of convenience

By 2030, the world settles into two confident accents of the same language. Each side can train, serve, and secure its own models without asking the other for permission. And yet, trade does not vanish. A thin set of bridges—file formats, inference APIs, evaluation checklists—remains open because it's useful. Researchers translate ideas across the gap; integrators keep a foot on each bank. The bridges are practical, not sentimental: they exist because commerce prefers adapters to embargoes.

11.2 Parity first in LLM training/inference; science follows later

The first domain to converge is language at scale. It is the most standardized workload, the most demanded service, and the easiest to measure. Clusters on both sides learn to push trillion-token diets through giant models with similar results, even if the routes differ. Scientific computing—CFD, climate, molecular dynamics—lags, because it is messier and more hardware-specific. That parity arrives, too, but on a slower clock, helped along by shared benchmarks and compilers that learn new dialects one kernel at a time.

11.3 Electricity becomes strategy; campuses turn power into product

Power stops being a line item and becomes the product itself. Winning campuses sign decades-long PPAs, co-site generation, and sell "compute with guarantees" the way factories sell capacity. Dashboards show not just tokens per second but **tokens per joule**, **time-to-energize**, and **grid services provided**. Some sites become civic infrastructure—batteries that steady local frequency, heat reused for district systems—earning the right to grow because they make the grid better, not worse.

11.4 Tools remain the tightest choke points

Chips are visible; tools are visceral. Compiler passes, EDA flows, signed firmware, packaging libraries, interconnect stacks—these decide who can actually ship. Access widens and narrows with policy and partnership, and every team learns the same lesson: keep a domestic path for the tools that can stop you, and never bet the company on a license you can't replace. The talent who can **operate** these tools—debug build chains, tame graph IRs, diagnose fabric stalls—become the most valuable hires in the building.

11.5 Packaging dictates pace through 2027

The calendar obeys the interposer. Lead times for HBM, substrates, and advanced assembly set the tempo for every grand plan. Smoother yields in 2027 ease the worst jolts, but the habit persists: design to what the package can actually deliver, not what the whiteboard can imagine. The winners are unfancy: steady suppliers, second sources, and board layouts that survive a part swap without a meltdown.

11.6 New siting champions outside the usual maps

The next big dots are not where last decade's cloud grew up. They're where **permits move**, **power is firm**, and **neighbors say yes**. Dry plateaus with long horizons. Port cities with old industrial grids. Energy provinces that see data as their next refinery. These places attract talent by offering something the big metros can't: a clear runway and a sense of ownership. Within a few years, their accents show up in papers, products, and the resumes of people who like to build.

11.7 Telco and finance anchor domestic accelerators

The first mass buyers of non-standard silicon are the ones who value uptime more than novelty. Call centers that must answer, networks that must route, ledgers that must reconcile. They pilot quietly, then reorder loudly. Once a telco core or a payments backbone trusts a domestic accelerator for a narrow set of jobs, the stack graduates from experiment to platform. Vendors harden drivers, compilers learn the company's traffic, SLAs get boring—exactly the way operations people like it.

11.8 Narrow licences return, but the frontier stays fenced

After a few hot years, policymakers rediscover the virtue of **specific**. Mid-tier parts, reference interconnects, and bounded tool access get licensed under tight guardrails. Everyone breathes a little easier in the middle of the market. But the very top end—cutting-edge training parts, bleeding-edge flows—remains gated. The compromise works because both sides need it: enough trade to keep ecosystems healthy, enough fences to keep red lines bright.

11.9 Fabrics and schedulers—more decisive than MHz

The hero of the back half of the decade is not a single chip; it is the **orchestra** that keeps thousands of them in time. Topology-aware schedulers, resilient collectives, placement that respects real-world links, checkpointing that forgives faults—these make average silicon feel excellent. Teams brag less about peak clocks and more about **job wall-times** and **fleet utilization**. A mediocre device on a great fabric beats a great device in a traffic jam. By 2030, everyone knows it, and the smartest resumes read: “Made the cluster sing.”

12. Wildcards and Turns

12.1 A breakthrough in cooling or site-adjacent generation

Every plan assumes today’s thermodynamics. A single surprise can rewrite them. Imagine **commodity direct-to-chip liquid** that installs like air and services like air—quick-disconnect manifolds, dry break couplers, spill-proof cassettes, and field techs trained in weeks, not months. Densities jump without drama; noise drops; power bills calm. Or picture **closed-loop heat reuse** that finally pencils: district systems taking steady 40–60°C waste heat, paying for what used to cost to throw away. Suddenly, the best sites aren’t only cold and dry; they’re **connected**.

The bigger swing is **generation at the fence line**. If modular, permit-friendly plants—long-duration storage, advanced geothermal, small modular reactors—arrive with utility-grade contracts, the siting map flips. Campuses become **power producers** that backstop the local grid instead of burdening it. Cities that once said “not here” start negotiating: “Bring your own megawatts, share your batteries, and we’ll find you land.” Cooling and electrons are the two doors; a breakthrough in either turns a bottleneck into a moat.

12.2 An interconnect leap that shrinks cluster tax

The quiet tax on giant jobs is the time lost to **talking**: all-reduce stalls, jittery links, topologies that punish the one tensor that won’t fit. A leap—whether optical to the rack, photonics in-package, or a new collective that routes around pain automatically—would feel mundane in the

best way: training curves smooth out, utilization climbs, and “end of job next Tuesday” becomes “Friday afternoon.”

If **programmable fabrics** go mainstream—switches and NICs that accept compiler hints at runtime—the stack finally behaves like one computer, not a thousand politely coordinating. Scheduler and interconnect learn each other’s moves; sharding adapts to real link health; failure domains stop cascading. The consequence isn’t a headline about terabits; it’s calendar math: the same cluster ships more models in the same quarter, and capital plans suddenly look generous.

12.3 A shared standard that spreads further than expected

Standards rarely arrive with trumpets; they arrive because they made **yesterday’s chore boring**. A portable **weights + graph IR** that retains enough structure for aggressive backend optimization could do this. If a lab can swap fabrics with a one-page checklist—and auditors can verify provenance with signed attestations—then portability moves from promise to habit. Vendors compete on execution instead of lock-in; buyers write RFPs that assume **boring migration**; open tools and proprietary stacks coexist because the handshake is honest.

Sometimes the surprise is social, not technical: a **benchmark suite** that the important labs trust, or an **evaluation ledger** governments accept across borders. If safety and performance claims travel with standardized evidence, the bridges between ecosystems thicken. Trade reopens where it is useful, not ideological, and middle-market buyers inherit a calmer world.

12.4 Climate shocks that reorder the siting map

The map we draw today is a climate bet. A few brutal summers, unexpected floods, or water restrictions that harden into law can flip columns in a spreadsheet faster than any policy memo. Regions that looked perfect on paper—cheap power, friendly permits—may discover **wet bulbs** that won’t forgive air cooling, or aquifers that can’t support open loop systems. Insurance costs become a line item no CFO can ignore; the “cheap site” turns out to be expensive when roads wash out or fires turn evacuation plans into real drills.

The inverse is hopeful: places once ignored—**high, dry plateaus; cool coasts with reclaimed-water projects; cities with district heating**—become havens. Operators who treated **resilience as design**, not decoration—elevated substations, dual water sources, onsite storage, heat-reuse partners—win by simply staying open. Climate doesn’t negotiate; it curates. The winners will be the campuses that planned for the 2030s weather, not the 2010s brochure.

13. Playbooks in Prose

13.1 For Policymakers: tie rules to power plans; speed without shortcuts

Write regulation as if you're designing a power plant, because you are. Every export limit, safety rule, and privacy requirement should be paired with an **energization pathway**: clear timelines for interconnection studies, fast-track permits for substations and cooling plants, and a predictable way to trade grid services (demand response, storage, heat reuse) for capacity. Make agencies synchronize—environmental review, land-use, water, and transmission—on a single calendar so projects don't die by a thousand sequential signatures. Ask for **evidence, not theater**: provenance of data, red-team logs, reproducible evaluations—lightweight but real. Be strict on outcomes (safety, reliability, water use) and flexible on methods. Build **escape hatches** into public procurements—dual-sourcing, portable formats, audit rights—so you never lock citizens into one vendor. And publish the scoreboard: time-to-energize, tokens per joule delivered, water intensity, uptime under heat waves. When rules see the grid and the grid sees the rules, speed stops looking like shortcuts and starts looking like competence.

13.2 For Builders: design for porting; buy bandwidth like oxygen

Treat portability as muscle, not myth. Freeze your **front-end** (the way teams write models) and let the **back-end** roam: rely on an IR that survives vendor swaps; keep kernels and quantization paths under version control you own; budget one sprint per quarter for "cold migration" drills so moving stacks is boring, not heroic. Profile the **fabric first**: plan topology from the workload backward; over-provision links where collectives will hurt; choose schedulers that see real link health, not brochure numbers. Spend early on **observability**—end-to-end traces, per-hop latency, per-rack thermals—so you fix causes, not symptoms. Co-design with facilities: power step-ups, water sources, plume and noise envelopes baked into your rack plan from day one. Your mantras: **tokens per joule**, **jobs per week**, and **time-to-answer**. If a shiny chip can't improve those three on *your* fabric, it's a distraction. Keep a "portable pack" for every model—weights, IR, tests, known-good configs—so a new cluster is a checklist, not an expedition. Above all, buy **bandwidth like oxygen**: it's invisible until it's gone, and then nothing else matters.

13.3 For Investors: back the seams—packaging, optics, and compilers

Alpha hides in the **joins**, not the logos. The defensible moats for the next five years are where systems meet: advanced **packaging** that tames yield and lead times; **optical interconnects** and switch silicon that turn rooms into one computer; **graph compilers/runtimes** that make porting dull and performance durable across vendors. Look for businesses that sell **certainty** as much as speed: predictable delivery of HBM assemblies, validated reference designs, drop-in fabrics with real SLAs, toolchains with measured wall-time gains on messy, mixed fleets. Favor teams with boots in both worlds—firmware and facilities, compilers and collective comms, substrate

vendors who can show you their second source. Insist on **operational metrics** over peak specs: utilization uplift, failure-domain containment, migration hours saved. And beware single-customer mirages: the winners will plug into many ecosystems because they speak IRs and APIs, not one badge. In short, fund the parts that make clusters **sing together**—the seams that compound across chips, sites, and years.

14. Conclusion: Practical Coexistence

14.1 The end of monoculture is not the end of progress

We did not lose momentum; we lost the illusion that momentum had only one path. The uniform era was efficient because it was narrow. This one is resilient because it is plural. Different regions climb with different gear, and the mountain still rises under all our feet. When one route ices over—policy, parts, or weather—another remains passable. Progress becomes less theatrical and more dependable: steady cadence in many places instead of a single drumbeat in one. The measure that matters is not who owns the tallest peak today, but how many summits are reachable tomorrow and how often the trails are open. Monoculture gave us speed; coexistence gives us continuity.

14.2 Why translation beats triumphalism

Triumphalism is a victory lap around a moving target. Translation is a craft that keeps value alive as the ground shifts. In a fragmented world, the winners are translators: engineers who carry models across fabrics without drama, policymakers who convert principles into workable permits, operators who turn heat into something a neighbor can use. Translation honors local constraints without abandoning shared aims. It creates room for cooperation without demanding uniformity. It is humble in method and ambitious in effect: less about proving a point, more about keeping promises—uptime, safety, fairness—when parts, rules, and climates change. Boasts grow stale; bridges age well.

14.3 Building a world where models travel even when politics don’t

We will not always agree, and we will not always trade. But we can still arrange the work so that ideas, tools, and protections move with fewer frictions than our arguments. That world is built from small, sturdy choices: formats that preserve meaning, APIs that do not break on schedule, attestations that make provenance checkable without ceremony. It is reinforced by habits—routine red-teams, shared evaluation notes, migration drills that keep portability a muscle, not a myth. It is licensed by communities who see that compute can stabilize a grid, cool a district, train a neighbor.

If we do this well, borders will shape architectures without strangling them. A model trained there can serve here; a fix discovered here can be verified there. The future will not be one stack to rule them all, nor a dozen walls to keep us small. It will be a practical braid of sovereignties, bound by translation, guided by guardrails, powered by places that said yes because we built with them, not over them. Progress continues—not as a single shout, but as many voices keeping time.

References

Export controls & policy

- Bureau of Industry & Security (U.S. Dept. of Commerce). *Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items; Supercomputer and Semiconductor End Use; Entity List Modification* (Interim Final Rule), Federal Register, Oct. 13, 2022. Federal Register
- BIS. *Implementation of Additional Export Controls: Certain Advanced Computing Items; Supercomputer and Semiconductor End Use; Updates and Corrections*, Federal Register, Oct. 25, 2023; clarifications Apr. 4, 2024. Federal Register+1
- ASML. *Statement regarding export control regulations Dutch government*, Jun. 30, 2023; *Statement regarding partial revocation export license*, Jan. 1, 2024; *Dutch government's updated export license requirement*, Sept. 6, 2024. ASML+2ASML+2
- Government of the Netherlands. *The Netherlands expands export control measure for advanced semiconductor manufacturing equipment*, Sept. 6, 2024. Government of the Netherlands
- Reuters. *Dutch government retakes export control over two ASML tools; service licensing clarification* (Sept. 6 & Sept. 10, 2024) and *Netherlands to expand export controls* (Jan. 15, 2025). Reuters+2Reuters+2

EDA access (May–July 2025)

- Reuters. *Synopsys halts China sales due to U.S. export restrictions (internal memo)*, May 30, 2025. Reuters
- Synopsys. *Statement: restrictions rescinded effective July 2, 2025.* Synopsys News Releases
- Reuters. *Cadence says restoring software access in China after U.S. lifts export curbs* (July 2–3, 2025); *Cadence raises outlook after curbs lifted* (July 28, 2025). Reuters+1

China domestic accelerators & deployments

- Reuters. *Baidu says its Kunlun P800 cluster can train DeepSeek-like models; 30,000-card deployment* (Apr. 25, 2025). Reuters
- 证券时报网 (STCN). *中国移动"人工智能推理服务器（GPU）采购项目"入围名单* — procurement packages including "CUDA-like ecosystem" category (June 2025). Yahoo Finance

- EE Times. *Alibaba unveils T-Head PPU AI accelerator; specs highlighted on CCTV; domestic 7 nm & 2.5D* (Sept. 23, 2025). EE Times
- Xinhua / 新华网. *Tencent Cloud discloses "Xingmai" high-performance computing network; supports 100k-card clusters* (June 29, 2023). Xinhua News
- InfoQ (CN). ***集群算力提升3倍，*** *腾讯云新一代高性能计算集群（星脉网络细节）* (Apr. 16, 2023). InfoQ

Company performance & market share signals

- Reuters. *Cambricon alerts investors after share surge; H1 2025 net profit ~¥1 bn; FY revenue guide ¥5–7 bn* (Aug. 28, 2025). Reuters
- Barron's. *China Has Its Own Nvidia… Cambricon's sales up ~4,000% to ¥2.88 bn (H1 2025)* (Sept. 2025). Barron's
- Morningstar / Dow Jones. *Cambricon first-half revenue +~44× to ¥2.88 bn; net profit ¥1.04 bn* (Aug. 26, 2025). Morningstar

Nvidia's China exposure & executive commentary

- South China Morning Post. *Nvidia CEO: U.S. not "far ahead" of China; calls for nuanced strategy; "100% out of China" remark at Citadel Securities event (Oct. 6, 2025)*. Supplyframe 四方维 - 赋能全球电子产
- Moneycontrol. *Jensen Huang says Nvidia assumes zero China revenue after export controls* (Oct. 7, 2025). Reuters

Power, siting & energy system context

- Our World in Data / Ember / Energy Institute. *Electricity generation dataset (2024); China ≈10,000 TWh* (underlying EI Statistical Review 2025). Our World in Data+2Ember Energy+2
- Reuters (Clyde Russell & Gavin Maguire columns). *China wind generation record* (Apr. 18, 2024); *Monthly generation snapshots 2025*. Reuters+1
- IEA. *Electricity 2024: Executive Summary & Full Report* — data centres' electricity use could exceed 1,000 TWh by 2026. IEA+1
- U.S. DOE / LBNL. *2024 Report on U.S. Data Center Energy Use* (Dec. 20, 2024). The Department of Energy's Energy.gov

Packaging, HBM & supply constraints

- Reuters. *TSMC to double CoWoS output in 2024; further increases in 2025; new packaging site in Chiayi* (Mar. 17, 2024). Reuters
- TrendForce. *TSMC CoWoS capacity expansion to ~75k wafers/month in 2025* (Jan. 2, 2025). TrendForce
- Reuters. *SK hynix HBM sold out for 2024 and almost sold out for 2025; HBM3E ramp* (May 2, 2024). Reuters
- Reuters (Breakingviews). *Samsung vs. SK hynix in HBM; share & supplier dynamics* (Sept. 23, 2025). Reuters

Frameworks, toolchains & portability

- MindSpore (Huawei) — official documentation portal.
- PaddlePaddle (Baidu) — official framework site (PyTorch/TensorFlow interfaces & APIs).

Provenance notes: Where possible, regulatory details are drawn from primary sources (Federal Register, government or company statements). Market, deployment, and capacity figures are sourced from major wires (Reuters, AP), official Chinese outlets (Xinhua), and respected industry trackers (TrendForce, EE Times). Energy system baselines use IEA, Energy Institute and OWID/Ember compilations.